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Sampling Error Quantification and Reduction - White Paper

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The primary error for typical destructive analysis (DA) of an inhomogeneous sample is the so called “sampling error” that occurs because different regions of the sample have a different ratio of g target/g sample mass. For MOX waste and powder this is especially important because the PuO_2 molecules tend to combine to make particles that vary in diameter from less than a micron to a hundred microns. As the waste is mixed and blended, these particles do not break apart to uniformly mix with the other waste materials. Thus, the Pu component in the waste remains somewhat non-homogeneous. When the waste is sampled, several separate grab samples are sent to DA to estimate the sampling error. Because of cost and waste from the DA process, the number of samples is kept low (typically 3), and the statistical uncertainty in a population of 3 is large.

The purpose of this note is to suggest a hybrid NDA/DA method to significantly reduce the sampling error, the DA cost, and chemical waste. The method would be focused on MOX waste by utilizing the intrinsic neutron emission rate from the plutonium. The idea is to take a larger number of grab samples (5-10), but only send 1 of the samples for DA after a preliminary NDA neutron measurement.

For the case of using the plutonium scrap multiplicity counter (PSMC), the individual grab samples would be measured in the PSMC for ~ 5 min. each to obtain the net singles rate. The net counting rate per sample would be measured and the average and mean rate per gram sample determined. The grab sample that was nearest to the mean would be selected to go for DA, and the remaining samples would be returned to their original container. The distribution in the neutron rates from the multiple grab samples would establish the potential sampling error for the Pu concentration in the waste, and the one sample that went to DA would be representative of the average Pu concentration in the waste, thus, removing most of the sampling error.

The singles rates from the MOX sludge that is being measured in the PSMC is in the range of $\sim 20,000 - 200,000$ cps, so a 1% grab sample would have a totals rate of ~ 1000 cps, and a 600s measurement would have $\sim 600,000$ counts. Thus, an order of magnitude smaller grab sample is usable.